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Lubrication

A Technical Publication Devoted to
the Selection and Use of Lubricants

THIS ISSUE
—
NEW HORIZONS
OF
GREASE RESEARCH



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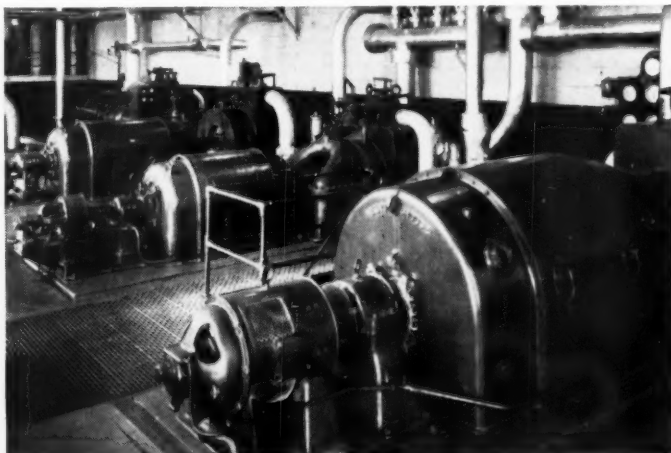
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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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NEW HORIZONS of GREASE RESEARCH

GREASES of one type or another have been manufactured for hundreds of years. In fact, it has been indicated that lime soap materials were used by Egyptians as early as 1400 B.C. for the lubrication of chariot wheel axles. It is natural to presume that these products were very crude partially saponified fatty materials. This prevailed for many centuries thereafter, for it was less than one hundred years ago that greases containing petroleum oils were known at all.

During the many centuries which preceded the age of mechanization, there was but little need for other than crude fatty lubricants. There were no high speed operations, and machines and methods of machining were very crude. It was not, in fact, until the advent of the automobile that any great demand for special greases arose. And even then there was a long period during which only "rule of thumb" and "trial and error" methods were used for the production of such lubricants. Only during comparatively recent years has research become a part of the evaluating and manu-

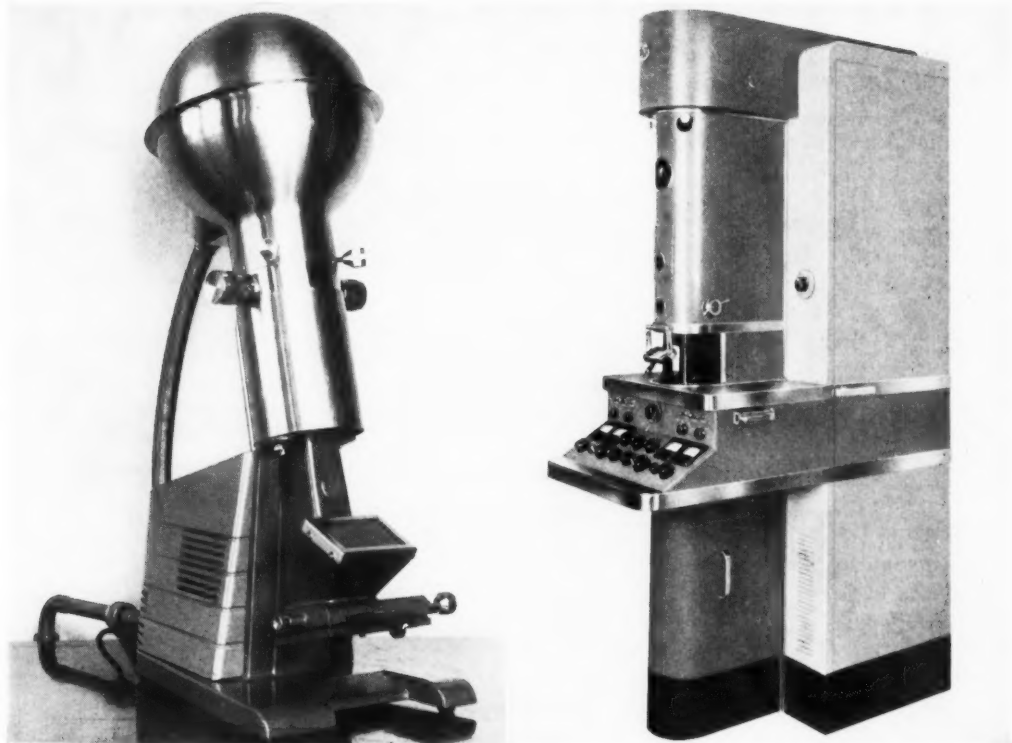
facturing procedure. Even so, during the development stage the grease makers without the benefit of scientific knowledge on the subject made many lubricants which were quite satisfactory for lubricating the equipment used during that period. The greases of thirty years ago, however, would hardly do for conditions of today. In turn, the lubricants of today will undoubtedly be far surpassed by the lubricants of the future.

During the days of lower speeds and less complicated machinery, grease making was strictly an art. It remained so for many years largely because of the complexity of the materials being used, the inclination of grease makers to guard their secrets, and the reluctance of institutions and refiners to spend large sums for funda-

mental research on other than the items of major importance such as gasoline and lubricating oils. In recent years that situation has changed. Because of greater and greater precision and higher and higher speeds, the need for specialized greases has grown tremendously. To supply these greases re-

THE TOOLS OF RESEARCH

The increase in mechanization, speed, and precision in industry during recent years has created a demand for many new and specialized lubricants. To aid in the development of these products, the petroleum research scientists have adapted intricate scientific apparatus to the study of the structure of petroleum lubricants. Such studies are of immeasurable value to the ultimate consumer. Through these studies the research scientists can furnish to the refinery accurate information on ingredients, additives, and manufacturing procedures necessary for the production of lubricants having the characteristics required for specific usage. Science is truly the hand-maiden of industry in the successful production and usage of modern lubricants.



Courtesy of Radio Corporation of America

Figure 1 — Left — Showing a permanent magnet-type electron microscope. The permanent magnets energize the magnetic fields that focus the beam of electrons used in place of light.
Right — Showing a universal model consol-type RCA electron microscope.

search has been necessary. Every large petroleum company now carries out a considerable program of grease research and expends considerable sums of money to develop lubricants suited to the needs of increasingly complex and demanding machinery.

Despite the increased emphasis on lubricants research, there are many problems which have remained unsolved. This is due in large measure to the lack of knowledge of the true fundamental nature of the soap-oil systems of which greases are formed. Results of changes in the systems could be evaluated and much knowledge has been gained on how to produce certain effects, but knowledge as to the causes of the effects has been difficult to obtain, largely because of the scarcity of tools available for such work.

Recently, new methods have been introduced to the field of grease research. With these new methods new vistas of knowledge have been glimpsed; new horizons of research have been opened for exploration. No one can predict the results which may ultimately be obtained, but it is certain that many advancements will be made in the field during the next decade.

Seeing the Unseeable

One of the greatest difficulties with grease research has been a lack of definite knowledge as to the true nature of the structure in the soap-oil system. It has been known for many years that these systems are highly complex, but there has been no way to see the actual structure of greases. Simple visual observation indicates that there is a considerable difference in the texture of various greases, ranging all the way from buttery products with no semblance of fiber structure to the extremely fibrous sodium soap greases.

Visual observation is not enough, however, to enable conclusion as to the nature of the soap structure in a given grease. More powerful tools are necessary. The most recent device for this work is the electron microscope.

Man is by nature, curious. He wants to see what is going on in the world about him. Early attempts were quite feeble in this respect but after the discoveries of Anton van Leeuwenhoek in the seventeenth century on the grinding of lenses, microscopes were gradually perfected which enabled the visualization of particles much smaller

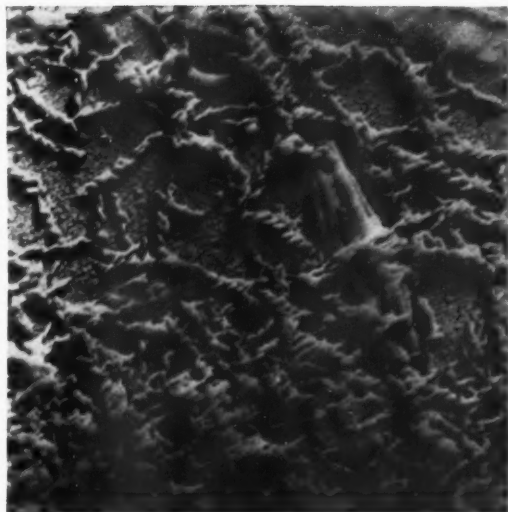


Figure 2 — Electron micrograph of a sample of cup grease.



Figure 3 — Another type of grease structure.

than can be seen with the unaided eye. But light microscopes have definite theoretical limits beyond which it is impossible to go. Even with the best microscopes, therefore, little was learned of the soap structure of greases because of the extremely small particle size involved. Progress in this field was temporarily halted therefore, until a device could be developed which would enable man to "see" even smaller particles.

In recent years, the electron microscope has been developed. This device uses a stream of electrons (extremely small electrically charged particles) instead of a light source, and magnetic fields are used to focus the electron beams in place of lenses as

in the case of the light microscope. With the electron microscope very small particles indeed can be photographed. As an aid to visualizing the extremely small size of objects distinguishable with the electron microscope, imagine for a moment that the smallest particle visible to the electron microscope were the size of the circle shown here ○ Then the smallest particle which can be distinguished with the most high powered ordinary microscope would be almost three feet across; and the smallest particle distinguishable to the human eye would be about as large as an average city block! Using this analogy in reverse, if a city block could be reduced till it was so small that it could



Figures 4 and 5 — Contrast these electron micrograph types of grease structure with Figures 2 and 3.

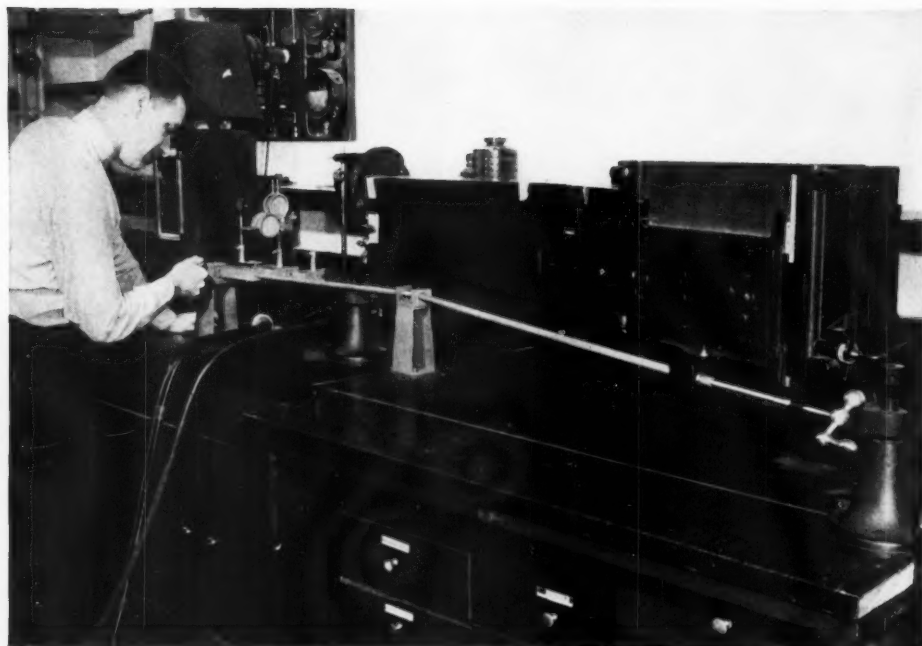


Figure 6 — Bausch and Lomb medium quartz spectrograph equipment in use.

be barely seen, then a light microscope could pick out a card table set on the original city block, and the electron microscope could pick out a small marble on this card table. With such equipment it has been found possible at last to determine the shape and configuration of the soap fibers in various types of greases. Photographs of an electron microscope are shown in Figure 1.

When greases are examined with the electron

microscope, a whole new vista is opened. Cup greases, for example, have been considered for years as buttery, nonfibrous greases. An electron micrograph of a sample of cup grease is shown, however, in Figure 2. It can be seen that the soap in cup grease is, in fact, fibrous, with the small individual fibers coiling about each other like a twisted rope. Experiments have shown that the amount of twist of the fibers is very definitely

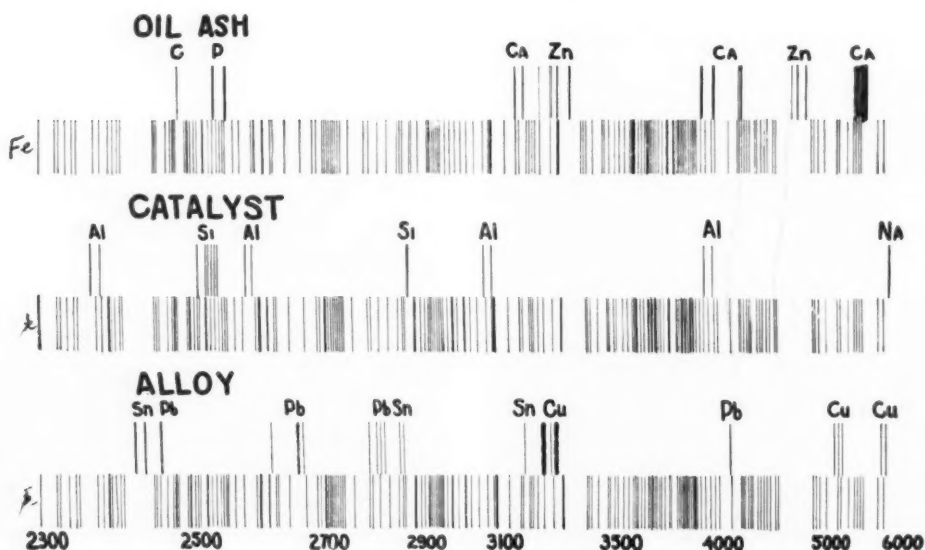
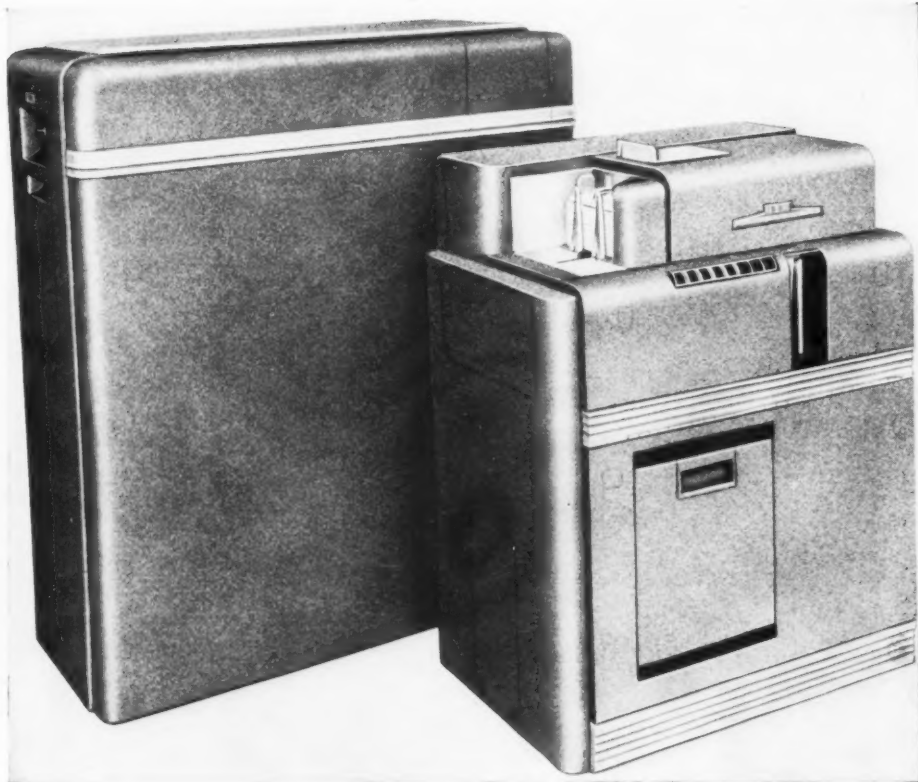


Figure 7 — Typical spectroscopic patterns.



Courtesy of International Business Machines Corporation

Figure 8 — IBM electronic calculating punch.

related to the extent of stirring during the manufacture. By means of this instrument, therefore, it may be possible eventually to correlate and control many of the variables of manufacture of various greases. This has not yet been possible, but may be a future result. It is one of the unexplored avenues of research.

Many different types of soap structure are found in different types of greases as illustrated in Figures 3, 4 and 5.

The application of the electron microscope to lubricants research is still in the very early stages of growth. As with any new scientific tool difficulties have been experienced; new techniques for handling very small samples must be developed; and because the information being obtained is new, a sufficient backlog of data must be accumulated before it can be properly interpreted. As time goes by, however, it may be anticipated that much information of real value will be obtained which will lead to a true understanding of the nature of greases.

The Language of the Atoms

Although the particles of matter discussed in the

preceding section are exceedingly small, there are yet smaller particles which are of great importance in the field of research. These are the atoms themselves. All material is made up of atoms which join together in various combinations to form molecules. Large groups of molecules form the particles discussed above. As powerful as the electron microscope is, the smallest particle which it can "see" is still a hundred times larger than an atom. Because the atoms are the fundamental building blocks of materials, however, it is very often necessary to know what kinds of atoms and molecules are present. Older methods for determining the presence of various compounds were often long and tedious; methods are now available to make the atoms announce themselves.

Atoms are made up of a central nucleus, in which is concentrated almost all of the weight, surrounded by electrons which travel in well defined orbits about the nucleus, much as the planets rotate about the sun. When the electrons are acted on by some external source of energy they may change their orbits, within definitely prescribed limits. When electrons change their orbits, light rays are given off; each different element emitting rays of definite



Figure 9 — A Bausch and Lomb research metallograph.

and distinctive wave length.

Practically everyone has at one time or another witnessed the colors of the spectrum which appear when sunlight is allowed to pass through a prism. The same effect is observed, of course, in the rainbow. The different colors are produced by light of different wave lengths. This is the principle of operation of the spectroscope. The light given off by the excited atoms is passed through equipment which separates the various wave lengths, and since each type of atom has its own distinctive wave length, a definite pattern of lines appears. Hundreds of patterns have now been identified and

cataloged so that a great many substances — both elements and compounds — can now be positively identified by the spectroscopic pattern. Further, the relative amounts of various materials can often be determined by the intensity of the pattern.

The ability to ascertain the presence, or absence, of certain chemical elements or compounds quickly and in very small quantities of greases will be a great aid in grease research. Here again the ultimate value of such equipment is difficult to imagine at the present time. It will undoubtedly be of increasing value as time goes by.

Something New in Arithmetic

The study of numbers and their relationships is very old indeed, and it seems hard to believe that anything new along this line could still be discovered. Progress is being made, however, even here, particularly in the means for applying some of the known relationships to research.

In a great deal of research work on greases and oils it is necessary to use methods of preparation and methods of testing which may be influenced by a great many variables. A single determination of a value is frequently very questionable. But even after many determinations, questions arise as to the true value. Often a simple arithmetic average is not the correct answer. It is like trying to determine the exact distance between two marks a considerable distance apart with a one-foot ruler. After numerous measurements, it will be found that many of the values obtained are very close together. Occasional other values may be quite a little different. The question then arises as to which of the values, if any, should be excluded in averaging the results obtained. The decision as to which values to accept and which to reject may be made on the basis of statistical analysis. Also, it is possible to determine from a large set of data, relating to a specific test, for example, which changes in values are significant and which are due only to variations in the test itself.

The principles of statistical analysis have been known for many years, but in many cases the mathematical calculations involved are so time consum-

ing that application of the methods has not been practical. This difficulty has been overcome to a great extent recently, however, by the development of mechanical and electronic calculators which are more than human in their handling of numbers. Calculations which once took hours or days can now be handled in a matter of minutes, mechanically and accurately.

Data can be sorted and correlated in a variety of ways very quickly. This is another example of progress in the line of equipment and in methods which will have a considerable bearing on research.

New Ways to Service

In addition to some of the equipment which provides new methods of attack on problems of grease research as such, there have also been advances in special equipment which are of primary benefit in providing services to customers, but which also will aid materially in lubricants research. Typical of such equipment is the metallographic microscope. This microscope differs from ordinary microscopes in that it is designed primarily for the examination of opaque surfaces, particularly metallic surfaces, whereas the usual instrument depends on transmitted light.

Such equipment is of considerable value in service. An instance in which the microscope proved to be a facile tool was in diagnosing the cause of a recurring series of bearing-to-journal seizures on a heavily loaded grease pressure lubricated roll neck bearing in a rolling mill. While a theoretical analysis

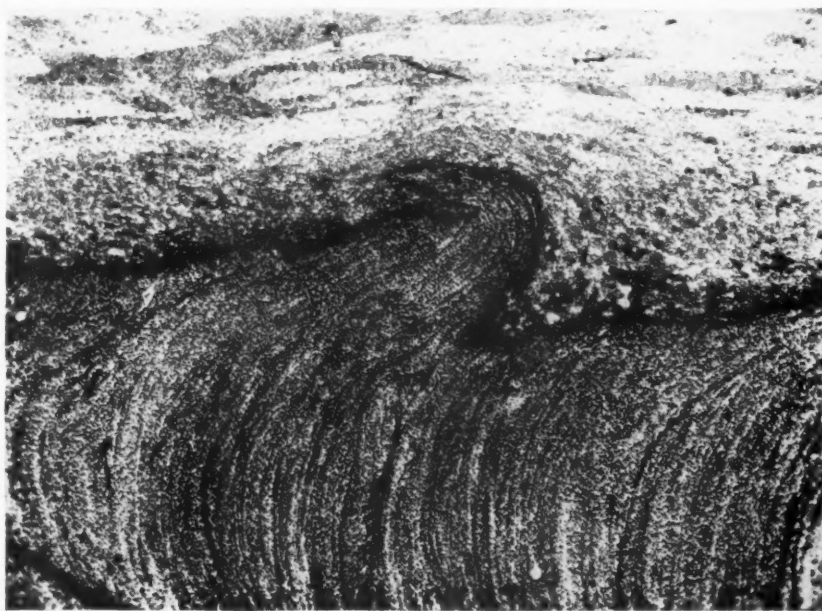


Figure 10 — Showing cross-section through a region of seizure of a bearing.

of the geometry of the running bearing (considering speed, load, size, and feed rate and body of the lubricant) indicated the installation should function satisfactorily, nevertheless, seizures were occurring.

Representative samples of the grease from a failed bearing, and a portion of the bearing metal itself, were submitted for microscopic examination. Two factors contributing to failure were detected.

The grease contained many particles of black, hard, mineral-like material recognized as fly-ash from the concern's power plant. On this point a subsequent investigation disclosed the fact that the grease hoppers supplying the lubricators were left uncovered and an abrasive ash from the near-by powerhouse gained ready access to the lubricant. In thin film lubrication, the presence of hard solids can disrupt the hydrodynamic film and thereby encourage metal-to-metal contact which, ultimately, can result in shaft seizure.

Examination of one of the seized bearings also contributed some vital information. Figure 10 represents a cross-section through a region of seizure: the lower, fine grained material is the steel shaft; the upper, lighter-colored portion is the bearing bronze. Whereas a lubricating grease film had once existed between these two regions which, under the magnification shown (50X), would be essentially flat, the steel and bronze now were intimately locked together by the severe welding when lubrication was destroyed.

A higher magnification of the bearing alloy is shown in Figure (11) where the grey background material is essentially a homogeneous solid solution of copper, tin and zinc. The white globules and crosses were found to be iron, considerably harder than the bearing metal itself.

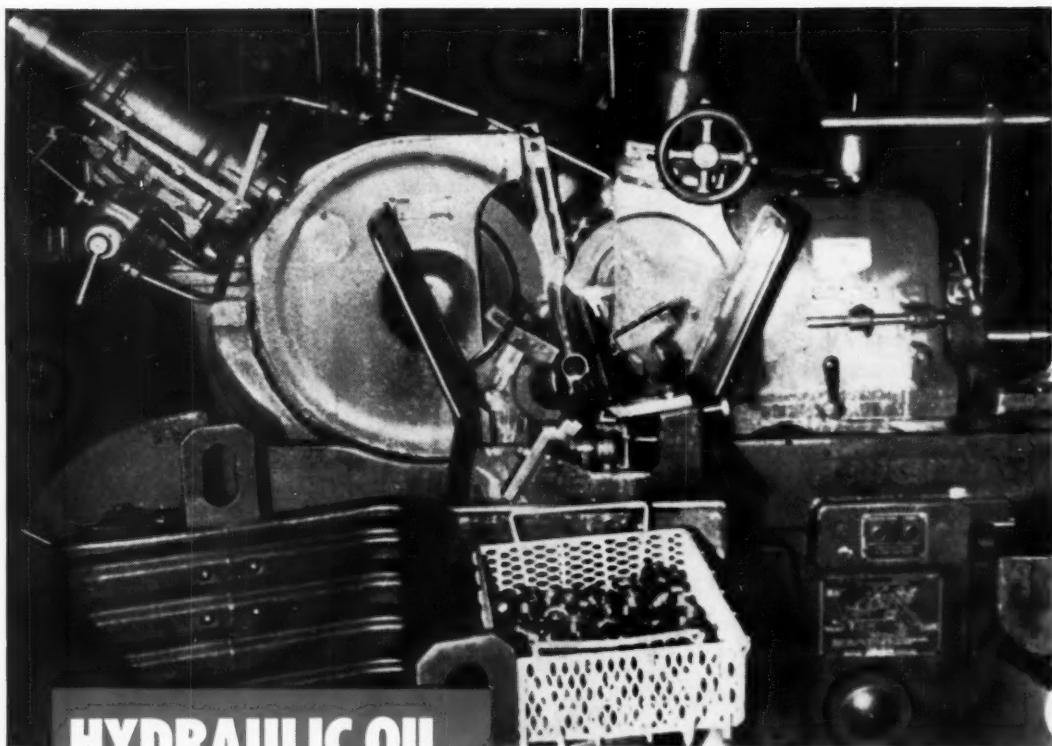
It is obvious that such a bearing material containing particles of the same degree of hardness as the mating journal would set up a very difficult lubrication problem, especially under the heavy loads and low speeds associated with rolling mill operation. In this particular instance, normal mill operation was restored by the substitution of a clean, leaded bronze bearing material and by providing a means of prohibiting the entrance of fly-ash into the lubricator.

Future Research

Although only a few of the newer implements for research have been reviewed here, it can readily be seen that activity in this field is very great. As time goes on, more and more specialized equipment will become available; and more and more will become known of the mysteries and intricacies of the fundamental nature of lubricants which have so long impeded the forward progress in this field. The horizons of grease research are indeed expanding and without question future research will yield much to enhance our present storehouse of knowledge.



Figure 11 — Magnification of the bearing alloy.



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